Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

XVII.

ON THE COMPARISON OF SOME ELECTRICAL CONDENSERS.

By Charles Nutt.

Presented November 12, 1890.

This article contains a comparative examination of some of the dielectrics most commonly used in condensers of large capacity.

Paraffine paper condensers are by far the cheapest, and for this reason it is desirable to know how good a condenser can be made using this substance as a dielectric. Certainly very great differences exist in paraffine paper condensers, and these differences are often due to the varying qualities of paper and paraffine used.

There are several kinds of so-called "paraffine papers" in the market, varying in thickness from tissue to heavy manilla. On account of small holes in it, two sheets of the tissue paper must be used between consecutive sheets of tinfoil.

One condenser made of this white tissue "paraffine paper," of about 2.5 microfarads' capacity, lost its entire charge in less than ten minutes. Its electrical resistance was less than a megohm. To be sure that the fault was not due to a few bad sheets, I tested the whole condenser by sections, all of which "leaked" badly. Other condensers made of this paper and of the similar brown tissue "paraffine paper" were as bad; some were worse.

Another condenser was very carefully made of the best quality of commercial paraffine paper, — a strong white rag paper of good texture, probably often used in condensers. Its capacity, as measured by discharging through the galvanometer immediately after charge, was 0.308 mfd. Its *resistance*, measured by an ordinary Wheatstone's bridge, was only 740 ohms! After loosening the clamps, the resistance fell to 250 ohms. When tested by sections, the insulation of the paper was shown to be uniformly poor. The presence of one sheet of this paper in a condenser would be enough to spoil it.

My experience seems to show that commercial "paraffine paper" is not fit for making condensers.

In preparing paraffine paper for myself, it was necessary first to decide upon the best kind of paper. I made a preliminary test, on small condensers, of ten sheets each, to find the comparative insulation of various kinds of paper. I put the condenser to be tested under pressure, and connected it in circuit with a battery of four gravity Daniell's cells and a mirror galvanometer. The throw of the needle was disregarded, and the permanent deflection due to the current through the galvanometer and condenser was read.

Papers.	Deflections.
Pulp (news)	1.0
Book, glazed,	0.3
Bond, glazed,	2.05
Bond, unglazed, No. 18	1.95
Bond, unglazed, No. 21	1.30
Tissue, brown commercial paraffine	1.20

This test showed that the cheaper kinds of paper were better than the bond and that the commercial paraffine was no better than ordinary clean paper.

A more careful experiment was made to see which of the three chief kinds of paper gave the best insulation. Condensers were made of pulp, pure rag, pure linen, bond (mostly linen), and of Ravelstone writing paper (rag and linen). Each contained ten sheets (21.5 × 34.5 cm.) with tinfoil (12.6 × 30 cm.). Four gravity cells were used. The galvanometer was much more sensitive than the one used in the experiments given above.

Papers.	Deflections.
Pure linen (mean)	43.7
" " (several hours later)	59.0
Rag	6.0
Ravelstone writing	11.25
Pulp (news)	4.6
Manilla	17.5 (?)
Bond	58.0

This last deflection gradually increased till it was "off scale."

Three days later, with the same galvanometer and condensers, but with fresh gravity cells, an even more conclusive test was made. The condenser made of ten sheets of the commercial paraffine paper, used in the second condenser described above, gave a violent deflection "off scale."

Papers.	Deflections.
Bond	81.0 *
Pure linen	50.5 †
Ravelstone writing	21.0 ‡
Rag	11.8
Pulp	3.6

---

* Then the deflection slowly crept "off scale."

† The deflection crept from 22 to this point, where it was still increasing.

‡ This deflection crept from 10 upward in a few minutes.

The rag and the pulp papers show no disposition to change in resistance while the current is passing, and they give decidedly the best insulation. The bond and the linen papers seem to have constantly changing resistances. The newspaper cannot be obtained free from holes and bits of metal. The rag paper, on the other hand, is of good texture, and admirably suited for our purpose.

The galvanometer used in the above tests is a form of ballistic galvanometer, devised by Professor B. O. Peirce of Harvard College. The coils have a resistance of 2764 ohms. The period of the needle is 53 seconds.

A deflection of one scale division (equal to a deflection of 10 millimeters with a scale distance of 2.8 meters) indicates a current of $8. \times 10^{-9}$ amperes. With four gravity cells, one division indicates the presence in the circuit of 500 megohms. The resistance of the paper may therefore be expressed in megohms.

CONSTRUCTION OF CONDENSERS.

The paraffine was taken from 15 lb. cakes. Experience showed that, while dipping the paper, care must be taken to keep out dust and dirt, especially coal-dust, and to prevent the paraffine from getting hot enough to smoke. Each sheet was examined before and after dipping for specks of dust and metal and for holes. Each was dipped, allowed to soak, and then cooled by itself.

The condensers are numbered for convenience, and briefly described.

Condenser No. 1 was made of sheets of bond paper dipped in the paraffine, with sheets of tinfoil between them. It was tested for leakage during the process of building and after it was clamped. The clamps in this and the other condensers to be described were strong oak boards of suitable size, bolted together so as to get a large and evenly exerted pressure on the condenser. The terminals of tinfoil at each end were wrapped about a thin strip of copper, from which a wire passed to the outside to make connections, and were held by a strip of board screwed to the lower clamp. These clamps, etc. were carefully insulated from the condenser. All of the condensers were built on a similar plan, — parallel plate condensers with half the tinfoil connected at one end, the alternate sheets making the other half at the other end.

DIMENSIONS OF No. 1.

Sheets of paper	80
Thickness of condenser	1.14 cm.
" of tinfoil	.05 "

Thickness of one sheet tinfoil	.00066 cm.
" of paper sheet	.014 "
Area of tinfoil (12.7 × 30)	381 sq. cm.
Capacity calculated for an equal air condenser by Ayrton's formula	.1827 mfd.
Capacity found by comparison with No. 72 (Elliott Bros.) standard microfarad condenser	.417 mfd.
Specific inductive capacity	2.28

Condenser No. 2 was made exactly like No. 1, except that it had 106 sheets of paper.

Condenser No. 3 was made of 104 sheets of paraffined rag paper, of the same size as the sheets in No. 1.

Condenser No. 4 was made of pulp paper similar to that used by the daily newspapers. It is tedious to make a condenser of this, on account of "leaks" caused by small holes and bits of metal. No. 4 has 72 sheets of the same size as those in No. 1.

Experiments with these three kinds of paraffine paper condensers confirmed the results of the paper tests. No. 3 is by far the best condenser. I concluded, therefore, to use the rag paper in the larger condensers.

Nos. 5, 6, 7, and 8 were made of rag paper similar to that of No. 3, and of the same lot of paraffine.

DIMENSIONS OF NOS. 5 TO 8.

Effective area of tinfoil 12.6 × 35 cm.	441 sq. cm.
Taking the specific inductive capacity as found, 2.28, we should require 67,437 sq. cm. of tinfoil for one microfarad capacity, or	153 sheets.

Condensers Nos. 5 and 6 required 154 sheets each to equal the capacity of the standard microfarad; No. 7 required 72 sheets to equal 0.5 mfd.; No. 8, intended for a tenth microfarad, contained 16 sheets.

Condensers Nos. 14, 15, 16, and 17 were made of the same lot of paper used in No. 5, but of harder paraffine. The melting point was determined at 51.5–52° C. No. 14 had 76 sheets; No. 15, 78 sheets; No. 16, 138 sheets; and No. 17, 16 sheets.

Condenser "G," also of paraffine paper, is an old instrument, made in the Jefferson Laboratory, of bond paper. It occupies a large uncovered box, and is held in place by paraffine, which completely surrounds and covers it.

Condenser No. 18, also of paraffine paper, was similarly protected by paraffine in a covered box.

I made a condenser of 12 sheets of bond paper soaked in boiled linseed oil. Its capacity appeared to be large, but it had a resistance of only 15,000 ohms, and an electromotive force of its own large enough to deflect the galvanometer "off scale"! By charging No. 72 with this electromotive force, I found it to be $\frac{1}{14}$ volt. Of course such an instrument is useless as a condenser.

Condenser No. 9 was made of sheets of hard rubber carefully cleaned and laid up. Paraffine paper was used to insulate the condenser itself.

DIMENSIONS OF NO. 9.

Mean effective area of tinfoil (12.6 × 24 cm.)	302.4	sq.cm.
Number of sheets	179	
Area of both surfaces of one set of tinfoil sheets	44,754	sq.cm.
Mean thickness of condenser	4.17	cm.
" " tinfoil sheets	.098	"
" " rubber "	4.072	"
" " single rubber sheet	.027	"
Calculated capacity of equal air condenser	.165	mfd.
Mean observed capacity	.389	"
Specific inductive capacity	2.35	

Gordon gives as a mean value for the specific inductive capacity of ebonite 2.28, though some of his specimens yielded the value 2.31; Schiller gives 2.76; Wüllner gives 2.56.

Condenser No. 10 was made of about 80 sheets of thin naked mica. The margin around the tinfoil was only about a centimeter.

Condenser No. 11 was made of 32 mica sheets (15.4 × 20.5 cm.), coated, for insulation, with pure shellac applied with a small brush.

Condenser No. 12 was made of 40 sheets of the same lot of mica used in No. 11, coated, for insulation, with paraffine.

Condenser No. 13 was made of 20 sheets of this same lot of mica, coated, for insulation, by dipping into a dilute solution of the shellac, and dried a week before they were used.

Condenser No. 72[*] is a mica condenser made by Elliott Brothers, London. Paraffine is used for insulation.

With these twenty condensers I have made a large number of observations, some of which will be found in the following tables. The first table shows the degree of insulation attained. The condenser was charged, then immediately discharged, and the reading recorded in the second column. It was then charged again, and disconnected for the time noted in the first column. The third column gives the throw of the needle at discharge, and the fourth the apparent percentage of loss.

---

[*] See these Proceedings, vol. iv. p. 145, "On the Charging of Condensers by Galvanic Batteries," by B. O. Peirce and R. W. Willson.

CONDENSERS NOS. 1 AND 2.

Minutes charged.	Throw of full Charge.	Throw at Discharge.	Loss Per Cent.
13.5	69.5	66.5	5.0
21.5	63.5	48.5	23.6
31.0	58.0	43.1	25.0
52.5	62.0	43.0	33.0
160.0	63.5	32.5	50.0
218.0	70.0	*29.5	58.0
2843.0	69.5	4.5	93.0

CONDENSER NO. 3.

31.5	39.5	39.5	0.0
57.5	39.5	39.5 (?)	0.0
164.0	37.5	33.3	25.0
265.0	34.5	*29.1	35.0
1400.0	38.53	20.2	45.4
2806.0	39.5	2.5 (?)	93.0
3877.0	32.3	7.5	76.7
5896.0	32.2	6.2	80.0
14400.0	32.0	1.0 (?)	97.0

CONDENSER NO. 4.

13.5	21.0	17.0	20.0
26.5	22.5	20.0	15.5
40.0	23.0	16.0	33.0
63.0	22.0	14.3	25.0
158.0	20.0	15.5	22.5
2635.0	22.0	7.5	65.0
4866.0	22.0	4.5	80.0

CONDENSER NO. 5.

69.5	60.0	*47.5	20.0
5894.0	58.5	4.5	92.0

CONDENSER NO. 6.

71.0	60.0	50.0	16.6
5894.0	58.0	3.2	93.0
14400.0	60.0	1.0	98.0

CONDENSER NO. 7.

76.0	29.3	23.8	18.0

CONDENSERS NOS. 14 AND 15.

2.0	63.5	62.0	2.0
3.5	63.0	62.0	2.0
3846.0	61.0	41.0 (?)	40.0
5858.0	57.5	47.6	17.4
8900.0	56.0	39.0	30.0

Condensers Nos. 16 and 17.

Minutes charged.	Throw of full charge.	Throw at Discharge.	Loss Per Cent.
2880.0	54.0	49.0	9.0
14400.0	57.0 (?)	11.5	80.0

Condenser "G."

2.0	47.5	*42.2	10.0
120.0	47.5	21.3	59.0
199.0	46.5	30.5	35.0

Condenser No. 9.

3.5	24.5	*23.2	5.0
246.0	25.5	23.0	9.8
3877.0	22.0	19.5	11.4
6166.0	20.7	14.5	30.0
11168.0	21.5	13.2	35.0

Condenser No. 10.

3.0	47.5	43.5 (?)	8.0
6.0	47.5	29.7	30.0
3877.0	47.5	0.0	100.0
5896.0	47.5	0.0	100.0

Condenser No. 11.

5.0†	9.0	*7.5	15.0
11.0	18.0	15.5	14.0
4233.0‡	30.0	1.0	97.0
8760.0	17.7	3.5	80.0

Condenser No. 12.

7140.0	9.5	1.5	85.0
8760.0	7.5	2.6	66.0

Condenser No. 13.

4245.0	13.5	0.7	95.0

Condenser No. 72.

27.0	58.3	49.8	17.0
1190.0	65.5	*42.0	20.0
3854.0	56.0 (?)	47.0	16.0
5760.0	60.0	*36.0	40.0
5906.0	53.5	40.0	25.2

---

† Before clamping. ‡ Before shellac was dry.

In these and all the remaining experiments the period of the galvanometer was 45.1 seconds. Unless otherwise stated, the measurements were taken by *discharging* through the galvanometer. Measurements marked with a star (*) were taken by *charging* the condenser through the galvanometer.

The following table of capacities was determined by comparing the condensers with Elliot Brothers' standard microfarad No. 72 by the throws of the needle of a ballistic galvanometer.

TABLE OF CAPACITIES.

(Mean Values.)

Condensers.	Microfarads.	Condensers.	Microfarads.
1	.417	10	1.09
2	.636	11	.352
1 and 2	1.06	12	.192
3	.597	13	.158
4	.368	14 and 15	1.04
5	1.05	16 and 17	1.06–1.11
6	1.08	16	.945
7	.506	17	.115
8	.109	72	1.00
9	.389	G	2.78

None of these condensers has an electromotive force of its own.

With a poor condenser, the value of the throw obtained by charging through the galvanometer differs widely from that obtained by discharging. With four typical condensers, Nos. 9, 10, and 14 and 15, I compared the two throws. The time of charge was 0.2 sec. In the first column is given the throw produced by the charge. As soon as the needle was brought to rest, the condenser was discharged through the same galvanometer, and the throw noted in the second column. The per cent loss and the intervening time occupy the third and fourth columns respectively.

CONDENSER NO. 9.

Charge.	Discharge.	Loss Per Cent.	Time in Minutes.
25.0	23.5	6.0	2.0
24.5	23.2	6.0	3.5
25.0	24.0	4.0	2.0
27.5	27.2	1.0	2.0
28.0†	28.1	0.5‡	2.0

---

† Left "soaking" to charge.

‡ Apparent gain.

Condenser No. 10.

Charge.	Discharge.	Loss Per Cent.	Time in Minutes.
27.3	23.0	16.0	3.0

Condensers Nos. 14 and 15.

63.5	62.0	2.3	2.0
62.3	61.5	1.1	2.0
62.8	62.5	0.4	1.5
63.7	62.5	2.3	2.5
63.0	62.0	1.3	2.5

When as short a time as 0.002 sec. was tried in charging Nos. 14 and 15, the discharge exceeded the charge, but the results were too irregular to warrant any definite conclusions.

The first column of the following table represents the full charge, the second column the first residual discharge, the third the following residual discharges after the intervals denoted in the fourth column.

Condensers Nos. 1 and 2.

Full Charge.	First Residual.	Following Residuals.	Time in Minutes.
69.0 [17.5[†]]	4.0	11.7[‡]	1.0
70.0	15.0	....	2.0
....	....	6.5	2.0
....	....	4.0	2.0

Condenser No. 3.

38.8	0.8	....	2.0
38.0	0.8	....	2.0
38.9	1.1	....	2.0
32.2	7.2	....	1.0

Condenser No. 5.

43.0	9.0	....	3.5
....	....	2.1	2.5
....	....	1.8	3.5
....	....	2.2	6.5
*67.3	13.0	....	2.8
....	....	3.5	2.5
....	....	2.1	2.0
....	....	3.0	2.0
58.5	10.8	....	2.0

[†] After 1090 minutes' insulation.

[‡] Equals sum of residual discharges the next 20 minutes at short intervals.

Condenser No. 6.

Full Charge.	First Residual.	Following Residuals.	Time in Minutes.
*60.0	9.0	....	2.0
*58.0	9.5	....	2.0
*72.0	12.5	....	....
44.0	9.0	....	3.5
....	....	2.1	2.5
....	....	1.8	3.5
....	....	2.2	6.5
56.5	10.0	....	2.0

Condenser No. 9.

14.5	0.6	....	2.0
20.7	1.2	....	2.0
*34.5	8.5	....	1.0
....	....	3.0	2.0
....	....	1.3	2.0
....	....	1.1	2.0
....	....	1.0	3.0
....	....	1.3	3.0
....	....	0.3	2.0
47.5	4.0	....	3.0

Condenser No. 10.

59.3	4.0	....	2.0
67.5	8.1	....	4.0
69.0	7.0	....	1.5
....	....	3.5	2.0
....	....	1.7	2.0
....	....	1.5	2.0
....	....	2.0	2.0
....	....	1.5	2.0

Condenser No. 11.

18.0	2.2	....	1.0
....	....	1.2	1.0
15.5	1.5	....	1.0

Condenser No. 12.

9.7	1.7	....	1.5
9.2	1.5	....	1.5

CONDENSERS NOS. 14 AND 15.

Full Charge.	First Residual.	Following Residuals.	Time in Minutes.
47.6	8.7	....	4.0
....	....	2.5	2.0
....	....	1.1	3.0
57.5	9.8	....	2.0
39.0†	7.7	....	2.0
CONDENSERS NOS. 16 AND 17.			
*64.5	12.5	....	2.0
*49.0	13.4	....	2.0
....	....	5.0	3.0
....	....	3.2	2.0
CONDENSER NO. 72.			
53.5	1.5	....	1.0
*65.5	3.1	....	2.0
‡60.0	7.5	....	2.0
....	....	2.5	2.0
....	....	1.5	2.0
....	....	1.0	2.0
....	....	0.8	2.0
....	....	1.0	3.0
....	....	0.8	2.0
....	....	0.5	2.5
....	....	0.6	1.5
....	....	0.6	2.0
....	....	0.3	2.0
....	....	0.3	2.0
....	....	0.3	2.0
....	....	0.1	2.0
....	....	0.1	2.0
....	....	0.1	2.0
....	....	1.2	6.0
....	....	1.5	22.0
....	....	3.0	28.0
CONDENSER "G."			
*49.0	26.0	....	1.5
....	....	2.4	3.0
*47.5	26.2	....	2.0
*43.5	29.5	....	3.0
....	....	3.5	2.0
....	....	1.0	2.0
....	....	1.0	1.0
....	....	0.5	2.0
47.5	12.5	....	2.0
....	....	5.3	2.0

---

† After long insulation. ‡ After long insulation 36 at discharge.

The time of charging was about 0.2 sec. The time was varied, but the results were not materially changed. I could not find a time of charging that would make the residue disappear. Of course the residue, as well as the charge itself, varies with the time of charging.

The following tables show the variations, with time of charging varying from 0.001 sec. to 30 sec., of the capacity of each condenser. The charging in short times was accomplished by means of the pendulum apparatus described in the Proceedings of the Academy, Vol. XXIV. p. 148. For longer times, a key was used. The measurement was made on discharging immediately after charging. All these measurements have been plotted, using the time in seconds for abscissas and the galvanometer deflections as ordinates. The curves are nearly parallel, and close to the axis of Y at first, but change rapidly, and in a good condenser become nearly parallel to the axis of X in a few seconds. The results give the means of four to ten observations. Where there is as much as two per cent disagreement in the observations, the mean is marked with a question mark. The time curve of a condenser is one of the best tests of its goodness. The capacities of leaky condensers vary greatly with the time.

CONDENSER No. 1.

Time in Seconds.	Throws.	Time in Seconds.	Throws.
.001	48.8	2.0	59.2
.012	51.0	3.0	60.0
.055	52.7	5.0	60.1
.098	54.1	10.0	61.1
.203	55.6	15.0	61.3
.295	56.1	30.0	61.8
1.0	58.4		

CONDENSER No. 2.

.001	40.0	3.0	45.4
.035	40.6	4.0	45.6
.125	41.6	5.0	46.0
.192	42.0	10.0	46.2
.209	42.2	15.0	46.3 (?)
.310	42.1	20.0	46.5
1.0	43.8	30.0	46.5 (?)
2.0	44.3		

CONDENSER No. 3.

Time in Seconds.	Throws.	Time in Seconds.	Throws.
.001	49.1	2.0	53.0
.011	50.0	3.0	53.8
.051	50.5	4.0	54.4
.100	51.1	5.0	55.2 (?)
.218	51.4	10.0	56.0
.326	52.0	30.0	56.6
1.0	52.3		

CONDENSER No. 4.

.001	30.0	1.0	33.0
.009	30.9	3.0	33.3
.038	31.3	5.0	34.7
.096	31.9	10.0	35.1
.210	32.5	30.0	35.3
.326	32.7		

CONDENSER No. 5.

.001	33.8	1.0	38.9
.013	34.8	2.0	40.0
.030	35.6	3.0	40.5
.061	36.4	4.0	40.9
.091	36.8	5.0	41.0
.158	37.4	10.0	41.5
.314	38.5	15.0	41.7
.326	38.4	30.0	41.9

CONDENSER No. 6.

.001	36.6	2.0	40.1
.028	38.2	5.0	41.0
.040	38.6	15.0	41.5
.301	39.6	30.0	42.4
1.0	39.8		

CONDENSER No. 7.

1.0	47.0	5.0	48.7
2.0	48.4	10.0	48.9
3.0	48.4	30.0	49.5
4.0	48.6		

Condenser No. 9.

Time in Seconds.	Throws.	Time in Seconds.	Throws.
.001	41.8 . . . 32.0	3.0	42.7
.022	41.8	5.0	43.1
.097	42.3	10.0	43.0
.192	42.8 . . . 33.0	15.0	43.0 . . . 33.6(?)
1.0	42.8	30.0	43.0 . . . 33.0
2.0	42.8		

Condenser No. 10.

.001	39.0	2.0	42.6
.005	39.5	3.0	44.0
.031	40.1	5.0	44.6
.150	40.5	10.0	45.2
.190	40.6	15.0	46.0
.300	40.9	20.0	46.7
1.0	41.3	30.0	46.6

Condenser No. 11.

.001	35.8	3.0	36.3
.120	36.0	4.0	36.3
.256	36.3	5.0	36.4
1.0	36.3	10.0	36.4
2.0	36.3	15.0	36.4

Condenser No. 12.

.001	12.5	4.0	12.57
.187	12.4	5.0	12.7
.315	12.5	10.0	12.7
1.0	12.5	15.0	12.7
2.0	12.55	30.0	12.7
3.0	12.5		

Condensers Nos. 14 and 15.

.001	40.0	0.270	40.8
.030	40.0	1.0	40.8
.0304	40.2	5.0	41.2
.051	40.0 (?)	10.0	41.2 (?)
.096	40.2	15.0	41.4
.102	40.0	20.0	41.4
.143	40.2		

Condenser No. 18.

.001	50.0	3.0	85.8
.122	68.5	4.0	87.5
.314	74.0	5.0	89.0
1.0	80.8	10.0	90.8
2.0	85.4	30.0	92.6

CONDENSER NO. 72.

Time in Seconds.	Throws.	Time in Seconds.	Throws.
.002	67.84	3.0	71.0
.025	68.30	4.0	71.0
.226	69.30	5.0	71.3
.340	70.48	10.0	71.15
1.0	70.80	15.0	71.6
2.0	71.0	30.0	71.2

These results indicate that, while hard rubber is probably the best dielectric for a standard microfarad, the paraffine paper condensers, Nos. 3, 14, and 15, and the standard, No. 72, are extremely well insulated and vary very little with time of charging. The experiments prove that a paraffine paper condenser can be made that compares favorably with a good mica condenser.

The mica condensers that I made "leaked" more than No. 72, because, I suspect, of the narrowness of the margin of mica around the tinfoil. The paraffine paper condensers gave larger residual discharges than either the mica or hard rubber condensers. That was their worst fault.

A paraffine paper condenser is necessarily much larger and heavier than a mica condenser of the same capacity, but far less expensive. In the tables below I have estimated the cost of the materials in microfarad condensers, using the three sorts of dielectrics that I found best adapted for making condensers.

Hard rubber	$30.00
Tinfoil	1.50
Clamps	.75
	$32.25

Mica	$10.00
Tinfoil	.50
Shellac	.25
Clamps	.75
	$11.50

Paraffine	$.75
Paper	.50
Tinfoil	.75
Clamps	.75
	$2.75

JEFFERSON PHYSICAL LABORATORY.
June, 1890.